

Contents

1	Introduction	1
1.1	Electronics	1
1.1.1	Brief History of Electronic Materials	1
1.2	The Importance of Semiconductors	3
1.2.1	Solid-State Electronics	5
1.2.2	The Integrated Circuit and Information Technology	6
1.2.3	Emerging and Growth Areas	7
1.3	Overview of Text and Suggestions for Use	7
	References	8
2	Junctions and Diodes	11
2.1	<i>pn</i> Junctions	12
2.1.1	Thermal Equilibrium and the Built-In Potential	12
2.1.2	<i>pn</i> Junction <i>I</i> – <i>V</i> Characteristic	19
2.1.3	Deviations from Ideal Behavior	29
2.1.4	Small-Signal Parameters	38
2.1.5	Transient Behavior and (Large Signal) Diode Switching	43
2.2	Metal–Semiconductor Junctions	49
2.2.1	Metal–Semiconductor Barriers (Blocking Contacts)	51
2.2.2	Metal–Semiconductor Ohmic Contacts (Non-blocking)	57
2.2.3	Deviations from Ideal Behavior	60
2.2.4	Small-Signal Parameters	62
2.3	Other Types of Junctions	65
2.3.1	Isotype Junctions	65
2.3.2	Heterojunctions	66
2.4	Applications of Single-Junction Devices or Diodes	67
2.4.1	<i>pn</i> Diodes	67
2.4.2	Schottky Diodes	69
	References	77
	Problems	78

3	Bipolar Transistors	81
3.1	Transistor Effect	83
3.2	Gain and Switching	90
3.2.1	Current Gain	90
3.2.2	Operation Modes of a Bipolar Transistor	94
3.2.3	Bipolar Transistor I – V Characteristics	97
3.3	Ebers–Moll Model	99
3.4	Deviations from Ideal Behavior	103
3.4.1	Base-Width Modulation	103
3.4.2	Punchthrough	104
3.4.3	Reverse-Bias Breakdown	104
3.4.4	Effects at Low and High Emitter Bias	106
3.5	Small-Signal Parameters	110
3.5.1	Frequency Limits of Bipolar Transistors	112
3.6	Optimizing Bipolar Transistor Design and Performance	114
3.6.1	Performance Versus Device Structure	114
3.6.2	Transient/Switching Behavior	116
3.6.3	Emitter Injection Efficiency	116
	References	120
	Problems	120
4	Field Effect Transistors	121
4.1	MOS Capacitor System	122
4.1.1	Flat-Band Voltage	124
4.1.2	Accumulation	124
4.1.3	Depletion	125
4.1.4	Inversion	125
4.1.5	Model for Charges in the Silicon Substrate	127
4.1.6	Deviations from Ideal Behavior	133
4.1.7	Capacitance of the MOS structure	134
4.2	MOSFETs	137
4.2.1	Long-Channel Theory	139
4.2.2	Refinements and Extensions to Long-Channel Theory	143
4.2.3	Subthreshold Conduction	147
4.2.4	Small-Signal Parameters	149
4.3	Integrated Circuit Applications and MOSFET Scaling	151
4.3.1	Comparison of BJTs and MOSFETs	151
4.3.2	MOSFET IC Applications	152
4.3.3	MOSFET Scaling	160
	References	171
	Problems	172
5	Emerging Devices for Electronics and Beyond	173
5.1	Nanoelectronics	173
5.1.1	Continued (MOSFET) Scaling	174
5.1.2	Alternative Devices and Architectures: Beyond CMOS	183

5.2	Microelectromechanical Systems	194
5.2.1	Materials and Structures	195
5.2.2	Applications	196
5.3	Biochips	201
5.3.1	Biomolecular Arrays	201
5.3.2	Lab on a Chip	203
5.4	Conclusion	208
	References	208
	Appendix A: Physics Primer for Electronic Devices	209
	Appendix B: Useful Data	253
	List of Symbols	267
	General Bibliography	273
	Index	275

Solid-State Electronic Devices

An Introduction

Papadopoulos, C.

2014, XIII, 277 p. 151 illus., 45 illus. in color., Softcover

ISBN: 978-1-4614-8835-4